Concentric and Eccentric Axial Load Test of Bolt-connected Prefabricated Composite Column

Hyeon-Jin Kim[1*], Hyeon-Jong Hwang[2], and Hong-gun Park[3]

[1*]Department of Architectural Engineering, Seoul National University, Seoul, Korea. *bultanun2@gmail.com*
[2]College of Civil Engineering, Hunan University, Hunan, China. *hwanggun85@naver.com*
[3]Department of Architectural Engineering, Seoul National University, Seoul, Korea. *parkhg@snu.ac.kr*

Abstract
Concentric and eccentric axial load tests on 2/3 scaled B-PSRC(Bolt-connected Prefabricated Steel Reinforced Concrete) and conventional SRC column specimens were performed. The experiment variables were the shape of vertical steel sections, the vertical spacing of transverse steel elements, the shape of transverse steel sections, the eccentric distance of axial load. Using concentric load test, The B-PSRC specimens showed similar degree of load-carrying capacity and deformation capacity compared to the conventional SRC specimens. Integrated section behaviors between concrete and steel angles were verified by eccentric load tests, showing well-fitted results with P-M interaction curves obtained from numerical section analysis.

Keywords: composite column, PSRC, bolt connection, confinement

1. Introduction

In the existing SRC composite column, H-shaped steel is generally located at the center of the cross-section. From a structural point of view, however, the full performance of the section can't be achieved under flexural load. As an alternative for structurally efficient composite sections and for better constructability, prefabricated composite column using steel angles (PSRC composite column, Figure.1b) was suggested. Steel angles are located at the 4-corners of the cross-section for greater flexural performance. Transverse re-bars for lateral stiffening are welded to the steel angle. Despite the enhanced moment-carrying capacity and constructability which comes from the removal of complicated reinforcement fabrication process, there are several problems caused by inevitable welding process between the steel angles and the transverse re-bars. To improve this weakness, the more developed B-PSRC which is fabricated by bolt connection between steel angles and transverse steel elements on behalf of welding the lateral re-bars was suggested.(Figure.1c) In this study, concentric and eccentric axial load tests were conducted on 2/3 scaled ten B-PSRC and four conventional SRC column specimens. Numerical predictions were performed to compare with the test results in terms of load-carrying capacity, deformation capacity, initial secant stiffness, etc.

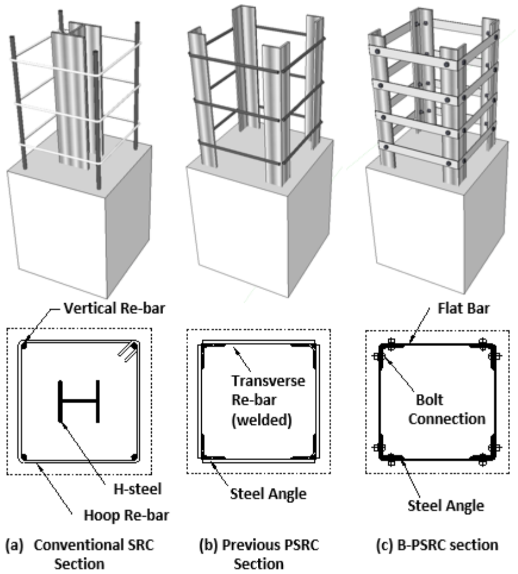


Figure 1. Comparison of three different columns
(a) Conventional SRC, (b) Previous PSRC, (c) B-PSRC

2. Test Program

2.1. Test specimens

Table.1 and Table. 2 presents the main parameters of axial load tests, material properties and section configurations of specimens. All specimens were designed for 2/3 scale, corresponding to 2200mm as column height and 500mm x 500mm for section dimension.

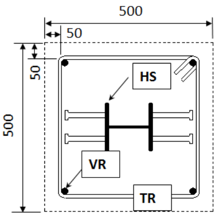
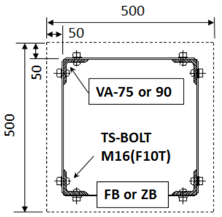
2.2. Test setting

Figure 2 shows the test-setups. Axial load was applied by a 10,000kN universal testing machine (UTM). Specially designed instrumentations are installed at the top and bottom of specimens to provide fixed boundary condition for concentric load tests and hinge boundary conditions for eccentric load tests.

Table 1. Material properties

Structural elements	Symbol	Yield Strength / Elongation (MPa, %)
Concrete	-	23, -
H-steel(140x140x8x10)	HS	502.2 / 32.3
Vertical Rebar (D19)	VR	554.0 / 18.6
Transverse Rebar (D10)	TR	564.7 / 7.9
Angle (L-75x75x9)	VA-75	378.3 / 34.0
Angle (L-90x90x7)	VA-90	
Transverse Steel(FB-40x3.2)	FB	353.0 / 40.2
Transverse Steel(ZB-30x50x30)	ZB	

Table 1. Main test parameters of specimens, test results and predictions

	Specimen	Main parameters				Test results						Predictions	
		$e^{(1)}$	Section configuration	$s^{(2)}$	Steel	P_u (kN)	ε_0 (3)	ε_{60u} (4)	K_i (5) (kN/mm)	K_p (6) (kN/mm)	μ (ductility)	P_n (7) (kN)	P_u/P_n
SRC	S1	0		250	HS & BR & TR	8,660	0.0022	0.0045	2,736	-1,416	2.03	7,195	1.2
	S2a	0		150		6,956	0.0021	0.0032	2,650	-981	1.51	7,195	0.97
	S2b	50				6,309	-	-	2,415	-1276	1.57	5,506	1.15
	S2c	150				3,091	-	-	1,107	-202	2.48	2,772	1.11
B-PSRC	S3a	0		250	VA-75 & FB	7,391	0.0016	0.0034	2538	-905	2.03	6,204	1.19
	S3b	50				5,029	-	-	2,380	-446	2.62	5,315	0.95
	S3c	150				3,019	-	-	1,125	-114	3.77	3,235	0.93
	S4a	0		150		6,358	0.0017	0.0111	2,404	-182	6.65	6,204	1.02
	S4b	50				5,951	-	-	2,210	-763	1.80	5,401	1.1
	S4c	150				3,967	-	-	1,410	-207	3.19	3,279	1.21
	S5a	0		250	VA-75 & ZB	7,934	0.0022	0.0041	2,345	-1,180	1.88	6,204	1.28
	S5b	50				5,422	-	-	2,044	-351	2.65	5,317	1.02
	S5c	150				3,444	-	-	1,366	-90	6.46	3,237	1.06
	S6	0		150	VA-90 & FB	7,722	0.0018	0.0046	2,407	-706	2.54	6,264	1.23

(1) Eccentric distance (mm)
(2) Vertical spacing of transverse steel elements (mm)
(3) The strain at the peak-load
(4) The strain at the 60% of peak-load after peak-load
(5) Initial secant stiffness
(6) Post-Peak axial secant stiffness
(7) Nominal strength in accordance with KBC2009 (in case that e=0) or Strength from nonlinear numerical analysis (in case that e≠0)

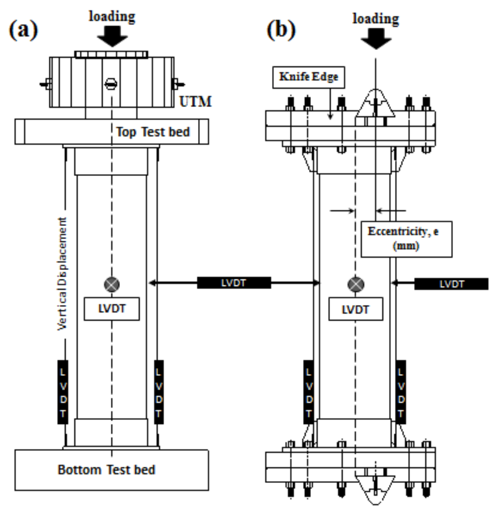


Figure 2. Test settings and LVDT measurement
(a) Concentric load test, (b) Eccentric load test

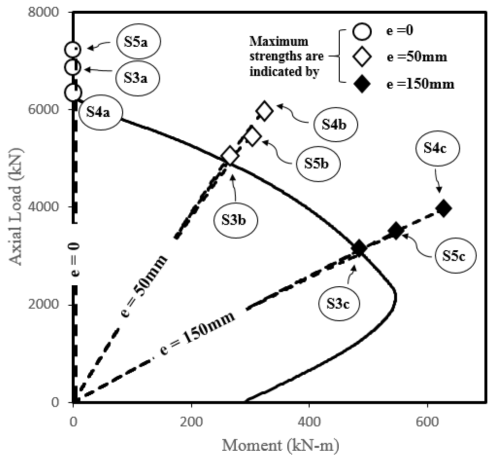


Figure 3. Test results and P-M interaction curve for the B-PSRC specimens

3. Test Results

The test results and the predictions from numerical analysis are listed in the right side of Table.1. Almost B-PSRC specimens showed the values larger than 1.0 in terms of the axial load strength ratio P_u/P_n. As shown in Figure.3, It is clear that the maximum strength points of all the B-PSRC specimens reached or are marked beyond the boundary line of P-M interaction curve obtained from numerical section analysis of the B-PSRC columns

4. Conclusions

B-PSRC columns showed the similar level of strengths compared to the nominal strengths of the columns obtained from the current design code. To decrease vertical spacing of the lateral steel elements enhanced deformation capacity by confining inner concrete tightly. Numerical analysis predicted the strength and deformation of the specimens fairly well. In addition, Integrated section behavior was verified from eccentric load tests, showing good performances.

5. References

Hwang, H. J., Eom, T. S., Park, H. G., Lee, C. N., and Kim, H.S. (2012). "Compression test for prefabricated composite columns using high-strength steel angles." *Journal of Korean Society of Steel Construction*, 24(4), pp. 361-369

Kent, D.C. and Park, R. (1971) "Flexural members with confined concrete, *Journal of Structural Division*, ASCE, Vol. 97, ST7, pp.1969-1990